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(54) Abstract Title
Aerial coupler for mobile telephones

(57) An aerial coupling device, suitable for coupling an aerial 11 of a mobile telephone 10 to the input of a measuring instrument, comprises a dielectric substrate 1 carrying at least one stripline 2 with a connector 9 at one end of the stripline and a terminating resistor 5 at the other end. In use a mobile telephone 10 is arranged such that its internal and/or external antenna is adjacent and parallel to a stripline. Plural parallel striplines may be arranged to extend from the connector 9 in phase opposition towards terminating resistors at opposite ends of a dielectric substrate. The striplines may have an impedance of between 50 and 377 ohms. An impedance transforming device and a 50 ohm coaxial cable may connect the striplines to the connector 9.

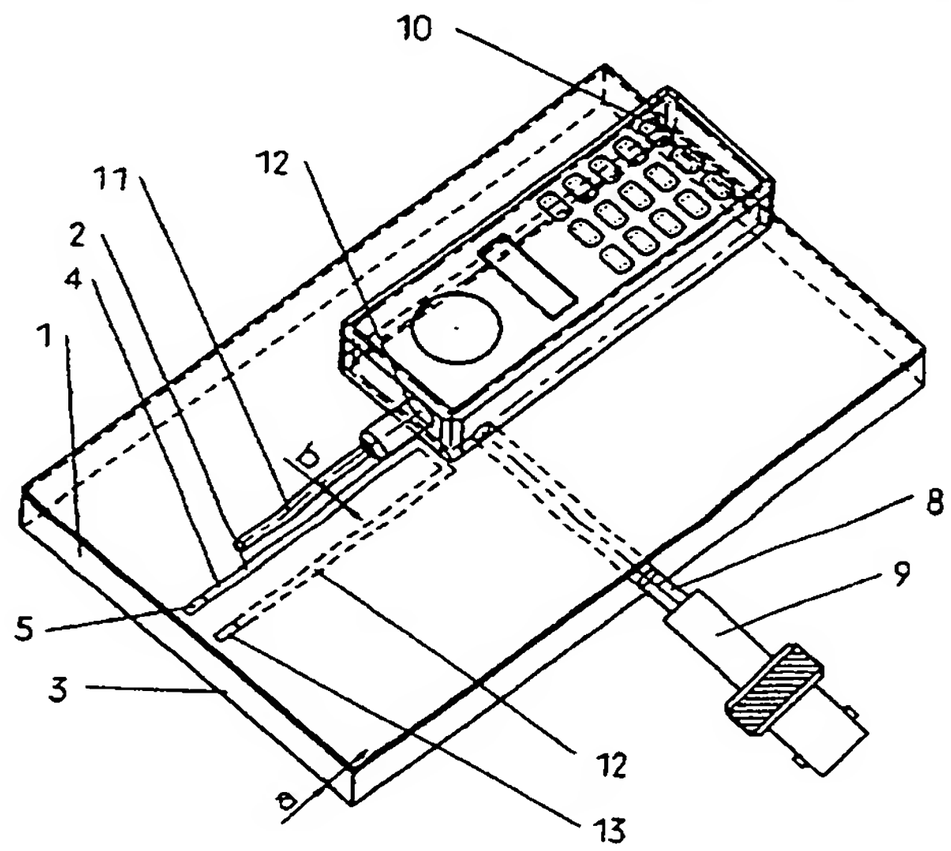

Fig. 1

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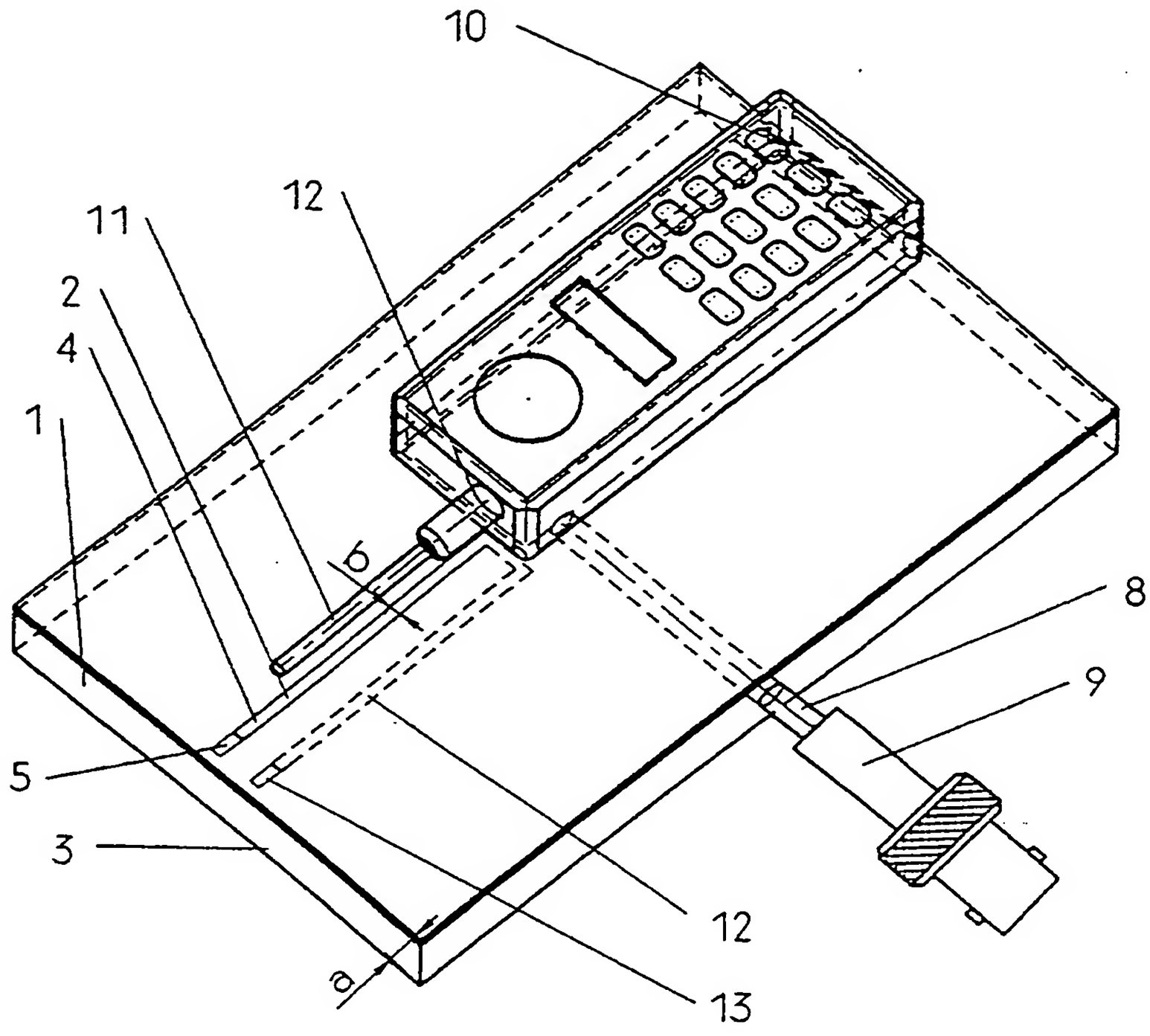

Fig. 1

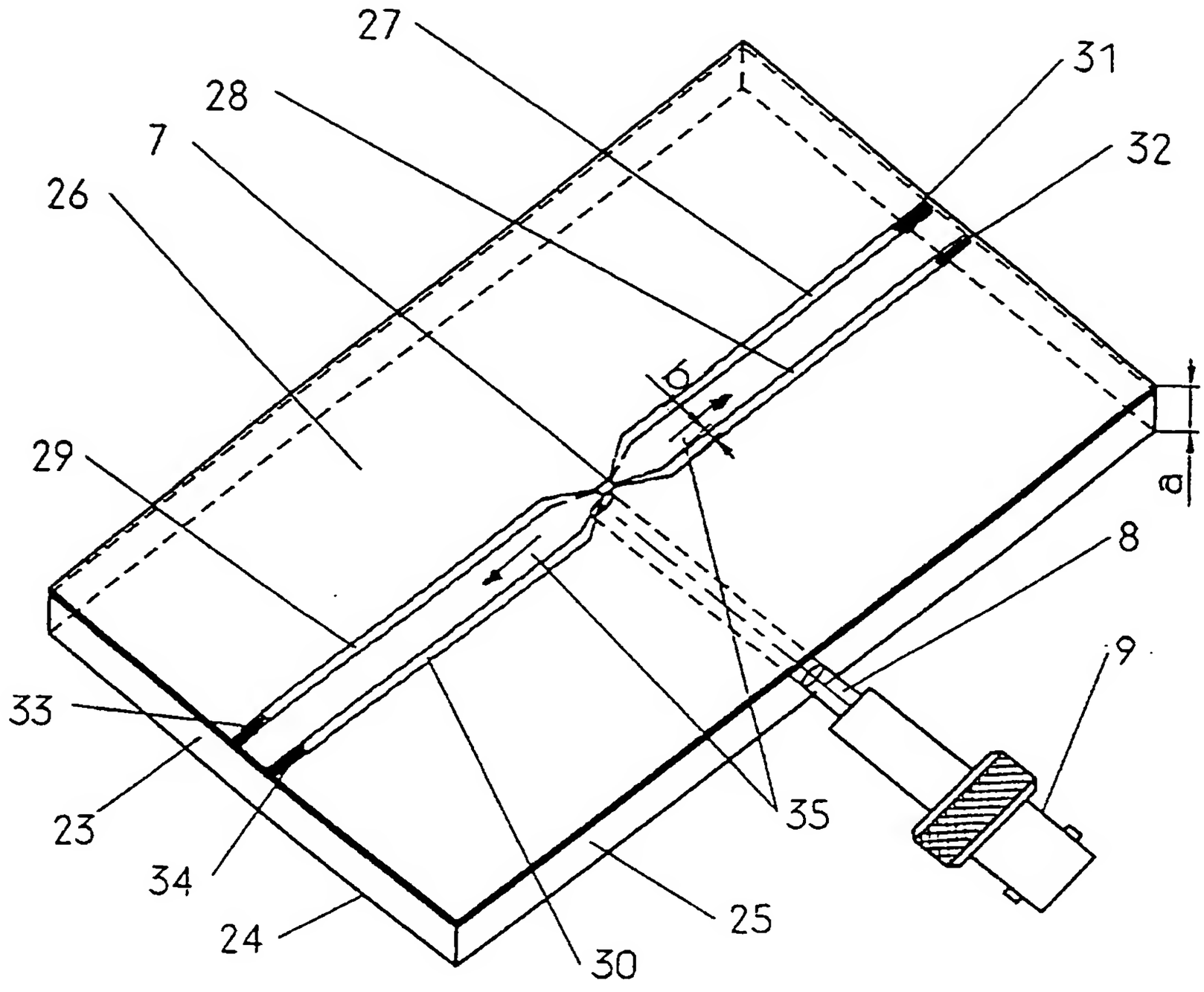

Fig. 2

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Aerial Coupler for Mobile Telephones

The invention relates to an arrangement for coupling the aerial of a mobile telephone to the input of a measuring instrument.

When manufacturing and servicing mobile radio handsets (mobiles) it is often necessary to carry out very precise radio-frequency measurements over a broad band using suitable radio-frequency measuring and test equipment. This requires the aerial of the mobile telephone to be connected at radio frequency to the input of the measuring or test instrument. If the mobile telephones that are to be tested do not have a separate aerial connection it will be necessary to use special aerial couplers. Various manufacturers of mobile telephones offer special aerial couplers in the form of coils, metal sleeves or short aerial rods, which are mounted on the aerial of the mobile telephone and can be connected to the input of the measuring and test instrument by means of suitable adaptor circuits. These conventional aerial couplers are not universally usable for the different types of mobile telephone. Increasingly mobile telephones no longer feature an aerial connection, and instead in most cases the aerials merely protrude partially from the body of the handset or even are fully integrated in the handset, thus making it no longer possible to use the conventional special aerial couplers.

It is therefore the object of this invention to create an aerial coupler suitable for all types of mobile telephones and enabling the aerial of the mobile telephone to be connected broadband to the input of a radio-frequency measuring or test instrument, even if the mobile telephone aerial is fully integrated in the handset.

Accordingly, the invention provides an arrangement for coupling the aerial of a mobile telephone to the input of a measuring instrument,

characterised in that formed on a plate of dielectric material is at least one stripline, at one end of which is provided a measuring instrument connection for connection to the measuring instrument's input, and the other end of which is terminated by a terminating resistor, and the mobile telephone that is to be tested is adapted to be set on the plate with its aerial parallel to the stripline.

In one embodiment, two or more striplines, the ends of each of which terminate with terminating resistors, are arranged alongside one another on the plate so that they start from the measuring instrument connection.

In a particular embodiment there are arranged on the plate, so that they start from the measuring instrument connection and run towards opposite sides, two or more striplines which are connected at their mutually facing ends to the measuring instrument connection in phase opposition and of which the other ends, facing away from one another, are in each case terminated with terminating resistors; the mobile telephone that is to be tested being adapted to be set on the plate in such a way that the base of its aerial lies in the region of the mutually facing stripline ends, its instrument body lies over one stripline and the aerial lies over the other opposing stripline.

The characteristic impedance of the stripline is typically selected to be greater than 50 ohms and smaller than the field characteristic impedance of the free space (377 ohms). More particularly, the characteristic impedance of the stripline can be selected to be between 100 and 300 ohms, for example approximately 200 ohms.

The terminating resistance of each stripline can be selected to be as big as the characteristic impedance of the stripline.

The measuring instrument connection can comprise an impedance

transforming device and a 50-ohm coaxial cable connected thereto.

The length of the striplines typically is selected to suit to the dimensions of the aerial of the mobile telephones that are to be tested.

The striplines can be in the form of asymmetrical micro-striplines with air as the dielectric. For example, the strip conductor of the micro-striplines can be formed on the reverse of a plate made of dielectric material, the plate being arranged at a distance (a) above a frame surface and being fastened at the edges of the frame surface which protrude upwards in the manner of a framework, and the terminating resistors being arranged as concentrated structural elements between the ends of the strip conductors and the frame edges. In such an arrangement, a 50-ohm coaxial cable adapted to be connected to the measuring instrument can be led from the reverse of the frame surface to the mutually facing ends of the striplines and can be connected in phase opposition via an impedance transforming device to the mutually facing ends of the striplines.

An advantage of the aerial couplers of the invention is that they are suited to all types of mobile telephones, even those on which the aerial protrudes only a little way from the handset or even is fully integrated in the handset. Furthermore the aerial couplers of the invention are adapted for broadband use and can therefore be used in the entire mobile telephone frequency range between 800 MHz and 2 GHz in use to date. The coupling attenuation is likewise extremely small, particularly in a case of an antiphase arrangement of a plurality of striplines. The coupling attenuation can be reproduced exactly and is more or less independent of the position of the mobile telephone on the printed wiring board carrying the stripline and also independent of the environment. In addition, the aerial coupler in accordance with the invention allows the mobile telephone to be used without hindrance during the test.

The invention is based on a knowledge of the fact that by appropriate choice of the characteristic impedance of the stripline terminating at the end, it is still possible on the one hand to adjust a sufficient concentration of the electromagnetic field in the vicinity of the stripline, yet on the other hand to generate a stray field sufficient for the electromagnetic coupling. Were the stripline to have a standard characteristic impedance of 50 ohms, the electromagnetic field would then essentially remain concentrated in the stripline and no stray field suitable for the coupling would develop outside the stripline in the region of the aerial of the mobile telephone placed alongside the stripline. On the other hand, the characteristic impedance must not be as great as the field characteristic impedance of the free space (377 ohms), for otherwise the field would be radiated into the free space. Therefore in accordance with the invention a compromise solution of 200 ohms is chosen as regards the characteristic impedance of the stripline; this characteristic impedance ensures that the stray field is not too extended, but still exhibits the necessary concentration in the vicinity of the stripline and therefore ensures in the best possible manner that the mobile telephone aerial is electromagnetically coupled to the input of the measuring instrument. The electromagnetic field is conducted along the line and not radiated.

The aerial coupler in accordance with the invention is suited to the most diverse types of measurement and test tasks, it can be connected via its preferably 50-ohm coaxial output to the radio-frequency input of any type of measuring, test and control equipment, notably bidirectionally, i.e. it is possible for the measuring instrument to actively test and measure the receiving part of the mobile telephone and/or, *vice versa*, for the transmitting part of the mobile telephone to be tested and measured in the measuring instrument.

Coupling the mobile telephone to the measuring instrument connected to the aerial coupler simply entails placing the mobile telephone onto the

plate carrying the stripline, with its aerial parallel to the stripline. The aerial coupler can be housed along with the mobile telephone in a closed metal box, thereby preventing the measurement from being disrupted by electromagnetic radiation from outside, for example from being directly affected by a mobile radio base station located nearby.

Suitable striplines include any conventional unscreened stripline arrays, as for example those described by Zinke & Brunswick, 'Hochfrequenztechnik 1' (=Electronic Engineering 1), 5th edition, pages 157-177, in other words so-called micro-striplines (microstrips), dual-band lines, coplanar lines, coplanar twin-band lines, asymmetrical coplanar lines or open slotlines. All of these striplines possess the characteristic that where they terminate with their characteristic impedance they possess an electromagnetic stray field that depends on the magnitude of the characteristic impedance and via which the mobile telephone aerial can be coupled to the input of the measuring instrument.

The invention will now be illustrated, but not limited, by reference to the specific embodiments illustrated in the schematic drawings.

Figure 1 shows the simplest layout for an aerial coupler in accordance with one embodiment of the invention. Provided on a plate 1 made of dielectric material is an asymmetrical microstrip line which is constituted by a strip conductor 2 on the front face of the plate and by the earth backing 3 on the reverse. The width b of the strip conductor 2 and the thickness a of the plate 1 (distance of the strip conductor 2 from the earth surface 3) are selected in consideration of the dielectric constant of the plate material, such that the characteristic impedance of this micro-stripline is around 200 ohms. The end 4 of the strip conductor 2 is connected to earth 3 via a terminating impedance 5, and this impedance is selected to be as big as the characteristic impedance, in other words 200 ohms. The opposite end 6 of the micro-stripline is connected via an impedance transformer 7 to a 50-ohm

coaxial cable 8, which is adapted to be connected via a plug connector 9 to the radio-frequency input of a measuring or test instrument (not shown), for example a compact test set-up CMD for mobile telephones manufactured by the firm Rohde & Schwarz.

In order to obtain as pronounced a stray field as possible above the strip conductor 2 and in order to prevent the electromagnetic field from being too heavily concentrated between the strip conductor 2 and the earth 3, a plate 1 is used which is made from a material having as small a dielectric constant as possible. Cellular foam is particularly suitable for this purpose, for this enables a dielectric constant almost of 1 (air) to be obtained.

To test the mobile telephone, it is placed on the top face of the plate 1, as shown in Figure 1, in such a way that the aerial 11 is lying more or less parallel above the stripline. Since, in the example of embodiment seen in Figure 1, the strip conductor 2 is formed on the top face of the plate 1, the surface is preferably now covered with a protective film in order to prevent the strip conductor 2 from making direct electrical contact. It can be seen from Figure 1 that the length of the plate 1 and the length 1 of the micro-stripline 2 are selected so that any commercially available mobile telephones can be positioned on the plate, namely so that the base 12 of the mobile telephone aerial 11 lies roughly in the region of the terminal end 6 of the stripline and the length 1 of the stripline is matched to the longest aerial of the mobile telephones that are to be tested.

In order, during measurement, to make the electromagnetic coupling between the mobile telephone aerial 11 and the stripline less dependent on the position of the mobile telephone in relation to the stripline, it is advantageous to provide two or more striplines, preferably parallel, on the plate, as is indicated by the dashed lines of the additional stripline 12, which in turn is of a size such that its characteristic impedance referred to the earth

surface is 200 ohms, and it in turn terminates at the end via a 200-ohm terminating resistor 13 to earth and at the terminal end is connected to the coaxial lead 8 via the impedance transformer 7. The striplines may also be arranged so that they fan out from each other.

In the case of the arrangement shown in Figure 1, the electromagnetic field is too heavily concentrated in the dielectric of the plate 1. It has therefore proved advantageous to construct the stripline using air as the dielectric, with the result that a stronger and nevertheless more concentrated stray field develops above the strip conductor of the micro-stripline. Figure 2 shows one form of embodiment of this. The earth surface is constituted by a shallow sheet-metal tray 23 whose edges 25 are bent upwards from a plane base surface 24 in the manner of a framework. On its upper face the shallow sheet-metal tray 23 is covered with a relatively thin plate 26 made of dielectric material, the edges of which are joined to the upwardly protruding frame edges 25. Formed with printed circuitry on the inside of this plate 26 are a total of four strip conductors 27 to 30, which with the opposing floor 24 of the metal tray 23 in each case constitute striplines with air as the dielectric. The distance a and hence the height of the laterally upwardly bent edges of the metal tray 23 and the width of the strip conductors 27 to 30 is again chosen so that these striplines have a characteristic impedance of 200 ohms, and the ends of the strip conductors 27 to 30 are again connected to earth (edge sections 25 of the metal tray) via 200-ohm terminating resistors 31 to 34. The striplines lying parallel alongside one another formed by the strip conductors 27, 28 and 29, 30 are fed in-phase via an impedance transformer 7, which in turn is connected to a 50-ohm coaxial power lead 8, whilst the opposing stripline halves formed by the strip conductors 27, 28 and 29, 30, respectively, are in each case fed in phase opposition, as is schematically indicated by the arrows 35.

A mobile telephone that is to be coupled is placed on the front face of the plate 26 above the striplines, in such a way that the handset body

thereof which acts as a counterweight to the aerial is situated above the strip conductors 29, 30, the base 12 of the aerial lies more or less in the region above the impedance transformer 7 and the mobile telephone aerial 11 lies in the region above the strip conductors 27, 28. This achieves particularly low coupling attenuation. The coaxial power cable 8 is preferably led over the reverse of the tray 23, underneath the impedance transformer 7, and then up through the floor of the metal tray until it reaches the impedance transformer 7 at the ends of the strip conductors 27 to 30; in this manner the electromagnetic stray field is least affected by the cable 8.

The use of terminated striplines as the aerial coupler means that the latter is very broadband and exhibits little interaction with the environment, something that could not be achieved using coupling aerials. Nor is this broad-band operation adversely affected by the use of a correspondingly broadband impedance transformer for the transition from the 50-ohm power lead to the 200-ohm stripline; commercially available miniature ferrite transformers have proved to be particularly practical in this regard.

Claims

1. A device for coupling the aerial of a mobile telephone to the input of a measuring instrument; the device comprising a plate of dielectric material having at least one stripline formed thereon; a measuring instrument connection being provided at one end of the stripline for connection to the measuring instrument's input, the other end of the stripline being terminated by a terminating resistor, the device being configured such that the mobile telephone to be tested can be set on the plate with its aerial parallel to the stripline.

2. A device according to claim 1 wherein two or more striplines are arranged alongside one another on the plate, the striplines starting from the measuring instrument connection and the ends of the striplines terminating with terminating resistors.

3. A device according to claim 1 or 2, wherein two or more striplines are arranged on the plate so that they start from the measuring instrument connection and run towards opposite sides of the plate, the striplines being connected at their mutually facing ends to the measuring instrument connection in phase opposition, and at their other ends, facing away from one another, being terminated in each case with terminating resistors; the device being configured such that the mobile telephone to be tested can be set on the plate in such a way that the base of its aerial lies in the region of the mutually facing stripline ends, its instrument body lies over one stripline and the aerial lies over the other opposing stripline.

4. A device according to any one of the preceding claims, wherein the characteristic impedance of the stripline is selected to be greater than 50 ohms and smaller than the field characteristic impedance of free space (377 ohms).

5. A device according to claim 4, wherein the characteristic impedance of the stripline is selected to be between 100 and 300 ohms.

6. A device according to claim 5, wherein the characteristic impedance of the stripline is selected to be 200 ohms.

7. A device according to any one of the preceding claims, wherein the terminating resistance of each stripline is selected to be as large as the characteristic impedance of the stripline.

8. A device according to any one or more of the preceding claims, wherein the measuring instrument connection comprises an impedance transforming device and a 50-ohm coaxial cable connected thereto.

9. A device according to any one or more of the preceding claims, wherein the length of the striplines is selected to suit to the dimensions of the aerials of the mobile telephones that are to be tested.

10. A device according to any one of the preceding claims, wherein the striplines are in the form of asymmetrical micro-striplines with air as the dielectric.

11. A device according to claim 10, wherein a strip conductor or conductors defining the micro-striplines is or are formed on the reverse of a plate made of dielectric material, the plate being arranged at a distance (a) above a frame surface and being fastened at the edges of the frame surface which protrude upwards in the manner of a framework; and wherein the terminating resistors are arranged, e.g. as concentrated structural elements, between the ends of the strip conductors and the said edges.

12. A device according to claim 11, wherein a 50-ohm coaxial cable adapted to be connected to the measuring instrument is led from the reverse of the frame surface to the mutually facing ends of the striplines and is connected in phase opposition via an impedance transforming device to the mutually facing ends of the striplines.

13. A device according to claim 11 wherein the strip conductor or conductors defining the micro-striplines is or are formed as printed circuits on the reverse of the plate.

14. A device for coupling the aerial of a mobile telephone to the input of a measuring instrument substantially as described herein with reference to the accompanying drawings.

15. A device as defined in any one of the preceding claims in combination with a mobile telephone.

16. A method of coupling a mobile telephone to a measuring instrument, the method comprising placing the mobile telephone on the plate of a device as defined in any one of the preceding claims such that the aerial of the mobile telephone is substantially parallel to the stripline(s).

The Patent Office

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Application No: GB 9808794.3 **Examiner:** J. A. Watt
Claims searched: 1 - 16 **Date of search:** 18 August 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G1U (UR2908, UR2910); H1Q (QHX, QKX); H3Q (QAA)

Int Cl (Ed.6): G01R 29/08, 29/10; H01Q 1/24, 1/27, 1/32; H04B 1/38

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
P, A	WO 97/17792 A1	(R J CROWLEY & D N HALGREN) published: 15.05.97, see fig.1 and page 9, lines 14 - 24	1
A	US 5557287	(MOTOROLA) see figs.1 - 4	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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